CHAPTER 2

People and Resource Use

❄ CRITICAL FINDINGS

Recent Population Growth Population doubled in the Sierra Nevada between 1970 and 1990; 40% of the population growth occurred in the Sierra portion of just three counties: Nevada, Placer, and El Dorado.

Population Forecasts Official projections forecast that the 1990 Sierran population of 650,000 will triple by 2040.

Impacts from Population Growth Population growth and its accompanying effects are causing significant impacts on resources.

Biotic Vulnerability The oak woodland communities of the western Sierra Nevada foothills are the most vulnerable of the widespread vegetation types as a result of greater access by humans and of their continuing potential for urban development.

Local Mitigation Some rapidly growing counties that SNEP examined have not collected information sufficient to adequately monitor and forecast impacts of development on biological and social resources. In addition, the current project-level approach to planning does not account for changes in regional or Sierra-wide conditions or address the need for larger-scale monitoring and improvement.

Jobs The number of jobs has more than doubled in the Sierra Nevada since 1970, but the relative proportion of commodity-producing and service-producing jobs has stayed constant.

Personal Income Income earned by commuters, interest, dividends, and transfer payments to retired and other households now constitute more than half the total personal income in the Sierra Nevada.

Ecosystem-Based Revenues Water is the most valuable commodity, followed by timber, livestock, and other agricultural products, based on gross revenues. The Sierra Nevada ecosystem produces approximately $2.2 billion worth of commodities and services annually, based on estimates of direct resource values (not the total revenue produced by resource-dependent activities).

Regional Patterns of Economic Activity The flow of economic values from the Sierra Nevada provides an empirical basis for assessing how different levels of government, producers and consumers, and employers and employees could be involved in new approaches to ecosystem management.

Community Dependence Communities in the Sierra Nevada are dependent on the ecosystem for a combination of direct and indirect natural resource benefits, including noneconomic benefits associated with aesthetic and sense-of-place values. Few economies are dependent exclusively on resource-extractive activities (timber, mining, grazing).

Timber-Based Employment Timber industry employment may decline from present levels due to trends of increasing labor productivity within the region and a shift in remanufacturing facilities out of the region.

Timber Harvests on National Forests National forest timber harvests have averaged 650 million board feet from 1950 through 1994; the highest level was just over 1 billion board feet in 1988, and the lowest was 227 million board feet in 1994.

Community Well-Being One hundred eighty communities were identified in the Sierra: twenty-eight ranked low and thirty-one ranked high in a measure of well-being that includes community capacity and socioeconomic status.

Regional Well-Being Six distinct socioeconomic regions were delineated by transportation corridors, commuting patterns, economies, community identification, and administrative boundaries.

Concentration of Low Socioeconomic Status Sierra residents living in poverty are concentrated in the larger cities and communities.

SETTLEMENT IN THE SIERRA

The Sierra Nevada is highly heterogeneous in terms of human settlement. Some parts of it are remote and inaccessible, while others are within easy commuting distance of rapidly growing metropolitan regions. Adjacent to the region's western boundary lies the Central Valley, where there are at least six rapidly growing urban centers, each with a 1990 population greater than 100,000. In contrast, the northern and eastern boundaries abut the sparsely populated high desert of the Great Basin. These areas are often isolated for months every year as winter snows either close or constrain travel on the mountain passes linking these rural areas to the rest of California. There are thirty-two counties (twenty-seven in California and five in Nevada) with all or part of their territory within the SNEP study region, but only twenty-two (eighteen in California and four in Nevada) of these counties include portions of the SNEP core area. Only ten counties (all in California) lie entirely within the boundaries of the region (figure 2.1).

Within 100 miles of the western foothills lie major metropolitan centers such as Sacramento, Fresno, Bakersfield, San

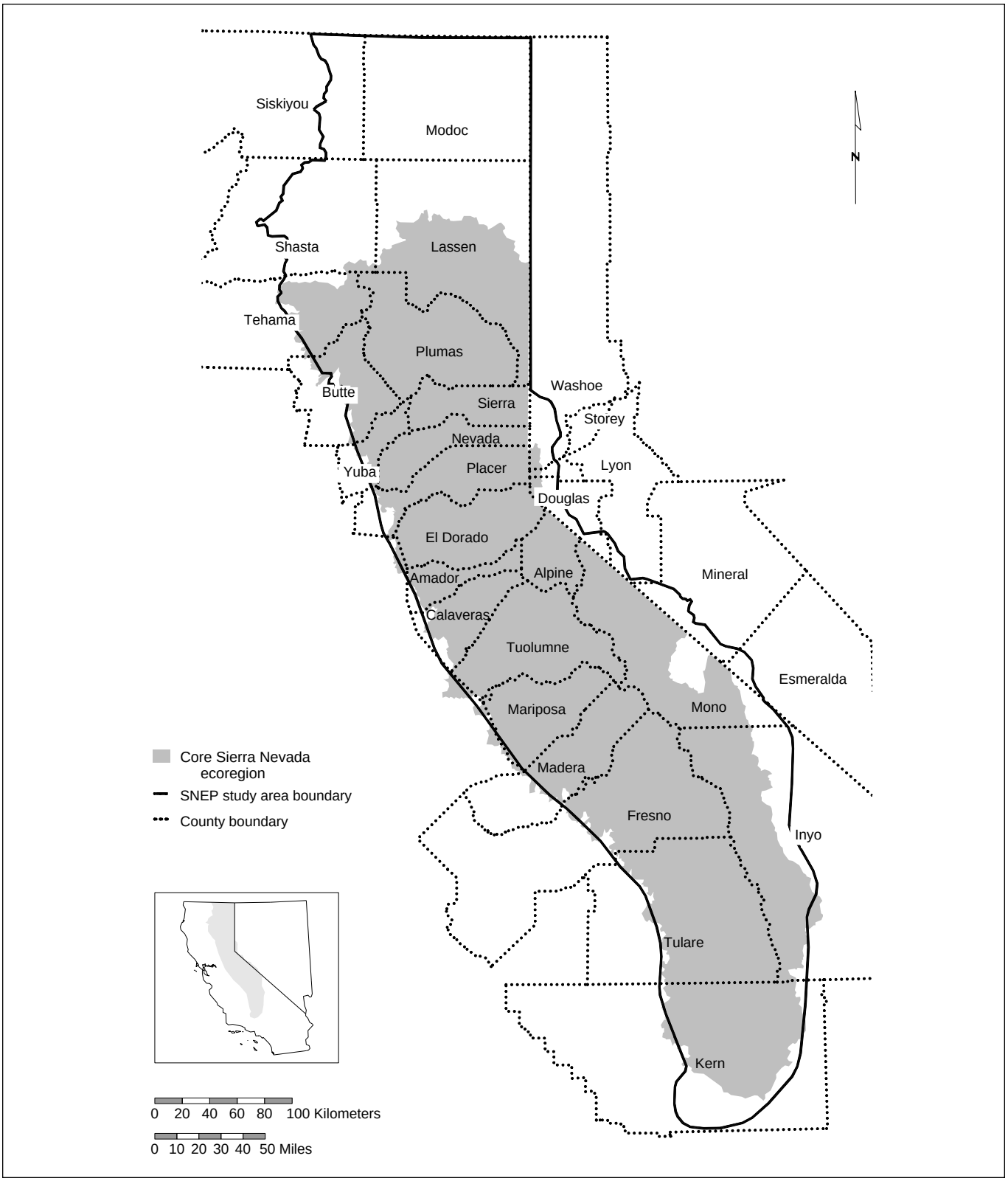


FIGURE 2.1

Sierra Nevada counties in California and Nevada. (From volume II, chapter 11.)

❄ *Deforestation in the Mid-1800s*

As towns and settlements grew during the post–gold rush years, circa 1850–80, the forests of the Mother Lode country were extensively changed. What we see there today is the result of human action that accelerated about 150 years ago. Native forests of mixed conifers were cut for housing and mine construction, and the lower edge of the mixed conifer belt shifted uphill. Exotics were planted in the towns. Seeds from the remaining pines fostered regeneration of pines on open sites (figure 2.2). Black oaks resprouted from stumps (foreground).

FIGURE 2.2

Nevada, California, 1856. Drawn from nature and on stone by Kuchel and Dresel. Lithographed by Britton and Rey and reproduced by their successors, A. Carlisle & Co., by Lithotone, for John Howell, San Francisco, 1935. (Courtesy of The Family of Joseph and Hilda Marinelli.)

Francisco, and Los Angeles. Major urban centers near the eastern flank of the Sierra are Reno and Carson City, both near Lake Tahoe. Interstate 80 and U.S. Highway 50 connect the Reno, Carson City, and Greater Lake Tahoe Basin regions to the Sacramento metropolitan area and the rest of northern California. This complex road network links the Sierra Nevada to social and economic activity throughout California and the world. It allows recreational visitors to access the wonders of the Sierra Nevada and provides avenues for the export of natural resources extracted in the range. The transportation network is therefore a primary determinant of the pattern of human settlement in the Sierra Nevada. It has determined the number of residents in the Sierra Nevada and their location over time. It also determines and reflects the relationship between humans and the resources of the Sierra Nevada.

Human beings have lived in and utilized the natural resources of the Sierra Nevada for millennia. Over the last ten thousand years and until the early part of the nineteenth century, Native Americans were sustained in the Sierra Nevada by hunting and fishing, gathering, tool quarrying, and trade. Population estimates for the Native Americans vary considerably, but in late prehistoric times (ca. A.D. 1300–1800), close to 100,000 from roughly thirteen tribes inhabited the region. Native American population densities were similar to current settlement patterns, highest below 4,000 feet on the west side of the range. Warfare, starvation, and the devastating epidemics of the 1830s dramatically reduced populations of native people.

Only four ships dropped anchor in San Francisco Bay in 1848, the same year that James Marshall discovered gold at Sutter's Mill near Coloma and the South Fork of the American River. The next year brought nearly seven hundred ships through the Golden Gate. Most of their passengers disembarked in the ports of northern California and promptly set out for the gold fields of the Sierra Nevada foothills. The region has been intensely inhabited ever since, and the patterns of settlement reflect the geography of both natural and human resources. The pattern of towns, roads, waterways, and related infrastructure established by the forty-niners continues to constitute the framework within which a new wave of

migration has swept over the Sierra Nevada during the past three decades.

Settlement patterns and resource utilization have historically reflected the export value of Sierra Nevada resources as commodities. Mining of Mother Lode gold deposits resulted in extensive settlement and intensive ecosystem change along a foothill belt just below the mixed conifer zone. In some areas settlement and ecosystem change extended into the ponderosa pine–black oak type, while other areas had concentrated activity only in the foothill grassland below. The new residents placed significant demands on nearby resources for timber, water, and agricultural production. Early mining activity led to significant timber harvesting and water diversions in higher-elevation areas that laid down the skeletal framework for today's hydrologic system. New demands were placed on higher-elevation resources by the Comstock Lode of Nevada and the building of the Central Pacific Railroad.

An estimated 150,000–175,000 people moved into the Sierra Nevada from 1848 to 1860, with up to one-third being foreign-born. These new residents further displaced the Native Californians, reducing their already diminished population by 75% between 1852 (the peak year of gold production in California) and 1860. Only 4,919 Native Americans were counted in the 1860 census. Chinese residents increased dramatically during this period, however, from around 6% of the total population (9,005) in 1852 to 18% (26,161 residents) by 1860. These census figures probably understate the peak numbers of Chinese residents considerably, because thousands of Chinese laborers helped to construct the Central Pacific Railroad across the Sierra Nevada during the 1860s (but were not necessarily present or accounted for in the census figures for 1860 or 1870).

Following a slight post-gold-rush decline, the population of the Sierra Nevada continued to grow, albeit slowly over the next century, not quite doubling from 150,000 residents in 1860 to around 250,000–275,000 residents by 1960. The ethnic composition of these residents became considerably less diverse, however, as Chinese residents dropped precipitously as a fraction of the population from about 12% in 1880 (20,642 residents) to less than 1% (3,347 residents) by 1920. Since then, the Sierra Nevada population has been overwhelmingly white. This pattern has persisted despite increasing ethnic and racial heterogeneity in the rest of California's population during the same period. In 1990, the Sierra Nevada was 92% white, compared with 69% for the state of California as a whole.

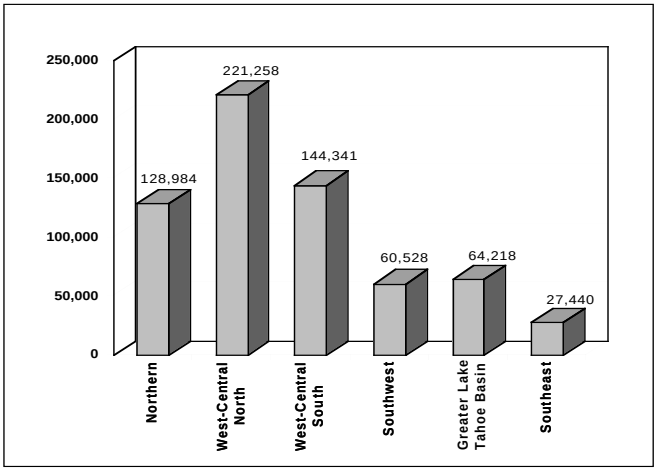
Construction of Interstate 80 and U.S. 50 have increased accessibility and changed patterns of resource utilization in Nevada, Placer, and El Dorado Counties. This area has become the focal point for the rapid population growth that more than doubled the Sierra population from about 300,000 people in 1970 to around 650,000 in 1990 (plate 2.1). More than one-third of the current Sierran population lives in this area. Figure 2.3 shows 1990 census population totals for six Sierra regions. These regions differ from hydrologic and other geographic regions and are based on transportation corridors, commute patterns, economies, community identification, and other information collected from local resident experts.

Current human settlement is not equally distributed across the Sierra, nor is it equally distributed across regions, a pattern that has significant implications for future land conversion and ecosystem impacts. Almost 70% of the total Sierra population is located in the west-side foothill zone. About two-fifths of all Sierra Nevada residents live on a total of roughly 89 square miles at an average housing density of at least 640 units per square mile (1 acre per unit). This land area constitutes less than 0.3% of the 32,000 total square miles of the Sierra Nevada. Approximately three-fifths of the residents live on about 298 square miles with at least 160 units per square mile (4 acres per unit) on a land area that constitutes just less than 1% of the total Sierran land base. Four-fifths of all residents live on about 1,471 square miles with at least 20 units per square mile (32 acres per unit). These residents occupy 5.4% of the total Sierran land base, or nearly 14% of all private land (including industrial timberlands). Up to 10% of the entire Sierra Nevada (3,905 square miles) may have been affected by human settlement in 1990, however, at an average density of at least 1 housing unit per 128 acres.

New residents are increasingly drawn by the amenity values of Sierra Nevada resources. Retirees, commuters, and exurban migrants are all coming to the Sierra Nevada at the same time that employment is declining in the traditional resource extraction industries, changing the social, economic, and ecological fabric of the area. The Sierra Nevada now has a very different age structure and ethnicity than the rest of California. There are more older residents and fewer in their twenties, as high school graduates leave the area for employment and school opportunities elsewhere. The new migrants are in

FIGURE 2.3

Sierra Nevada population in 1990 by region. (From volume II, chapter 13.)



utilization at three points during the past 150 years. Utilization of any single resource has never been constant or sustainable for the whole period but the Sierra Nevada as a whole has constantly produced large quantities of valuable resources. Since the 1884 *Sawyer* decision to limit hydraulic gold mining because of environmental damage, resource utilization has been governed to protect broad social interests.

Resource utilization in the Sierra Nevada has always been closely intertwined with the markets and institutions of urban California. For resources other than gold and other minerals, linkages to urban markets often had more influence on utilization patterns than the availability of the natural resources themselves. After the destructive clearings of the foothills during the first years of the gold rush, timber harvests in the higher-altitude and less accessible regions were limited by the relatively small size of California markets and cheaper im-

ter 1884 was the result of court injunctions stemming from the damage done downstream by hydraulic mining debris. The capture of Owens Valley water to promote urban growth in Los Angeles rather than a federally financed reclamation project is the most well known example of the value of a resource in a distant urban area dominating its potential value within the Sierra Nevada.

Opening the Sierra Nevada: 1848–1900

The discovery of gold at John Sutter's mill in 1848 began a series of boom-and-bust cycles of resource utilization. During the 1850s, the Sierra Nevada produced nearly half the world's gold output and spurred an enormous migration to California. By 1860, the 25,000 gold miners had collected the easily accessible placer gold deposits, and many miners left

FIGURE 2.5

Resource utility indices in the Sierra Nevada for three periods: 1880s, 1950s, and 1985–95. (From volume III, chapter 23.)

Hydraulic mining, Malakoff Diggins State Historic Park, North Bloomfield, Nevada County, Humbug Creek, tributary to the South Yuba River. (Photo by Timothy P. Duane.)

or shifted to other resource-related work. Twenty years of hydraulic mining begun in the 1850s created an enormous amount of sediment and altered the river systems for decades. Large areas of the foothills were cleared and converted to farms and grazing lands to supply the growing population of California and Nevada. More land in the Sierra Nevada was under cultivation in 1860 than in any year since.

Thousands of acres of forest were cut each year to provide timber for mining structures and houses. The completion of the trans-Sierra railroad in the 1860s allowed timber to be sold to the growing Central Valley, and even San Francisco, in addition to local mines and towns. Timber harvests for the Sierra Nevada region during the late 1800s averaged over 500 million board feet, with most coming from the western foothill region. By 1880, over 1.5 million acres of pine forests had been cut or burned in the western foothills. By the late 1800s, the foothill landscape was a mix of cutover forests, grasslands, burned areas, and agricultural fields. In the higher elevations, difficult access and lower prices for species other than the pines limited timber harvesting and the associated fires that affected the lower forests.

Cattle grazing increased fivefold in the first decade of the gold rush and stayed at these high levels for the next century. Sheep proved to be more effective harvesters of the higher-elevation meadows. By 1870, sheep ate more grass than did cattle in the Sierra Nevada and probably caused considerably more ecological damage than cattle. It is widely acknowledged that the essentially unregulated grazing led to ecological damage still visible across much of the Sierra Nevada.

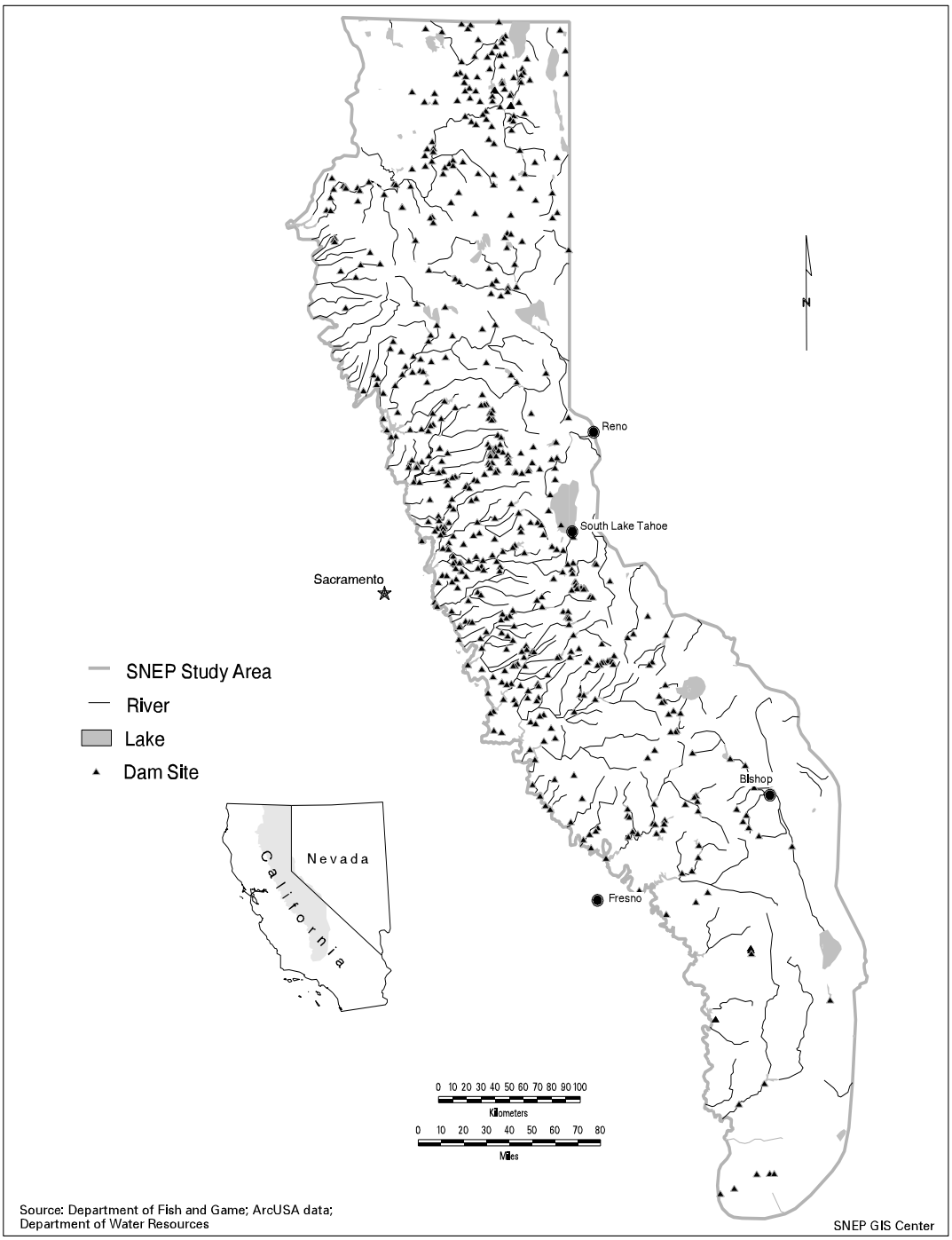
One of the most enduring legacies of the 1800s is the physical and institutional impact of water diversions in the mining camps and the surrounding farms. The need to divert water to make it useful for the mining communities led to the "first in time, first in right" miner's code that eventually became enshrined in California water law. Water diversions through ditches or wooden flumes crisscrossed the Sierra Nevada to create financial wealth by reordering hydrologic processes. Even after the restrictions on hydraulic mining in 1884, the ditches continued to be used for irrigation and power production for many widely dispersed but relatively small operations.

More than 300 communities grew up in the Sierra Nevada

Timber harvest from federal and private lands in the Sierra Nevada, 1948–93. (From volume III, chapter 23.)

FIGURE 2.9

Location of dams greater than 25 feet in height or 50 acre feet in volume on streams in the SNEP study area. (From volume II, chapter 35.)



understanding of how diversions, economic benefits, and ecological impacts are linked.

The rivers of the northern Sierra Nevada have been extensively diverted in both the upstream and the foothill stretches. The central rivers draining the western side have been moderately diverted upstream and heavily diverted in the foothills (only one small river is allowed to flow into the Central Valley without a major dam and reservoir). The southernmost rivers have been moderately diverted in both the upstream and the foothill stretches.

The dominant purpose of the dams varies by location. Two-thirds of foothill reservoir capacity is managed to provide irrigation water to the Central Valley. Conversely, two-thirds of upstream reservoirs are managed to provide municipal water supplies and hydroelectric power. This difference suggests that efforts to reduce the negative ecological impacts of up-

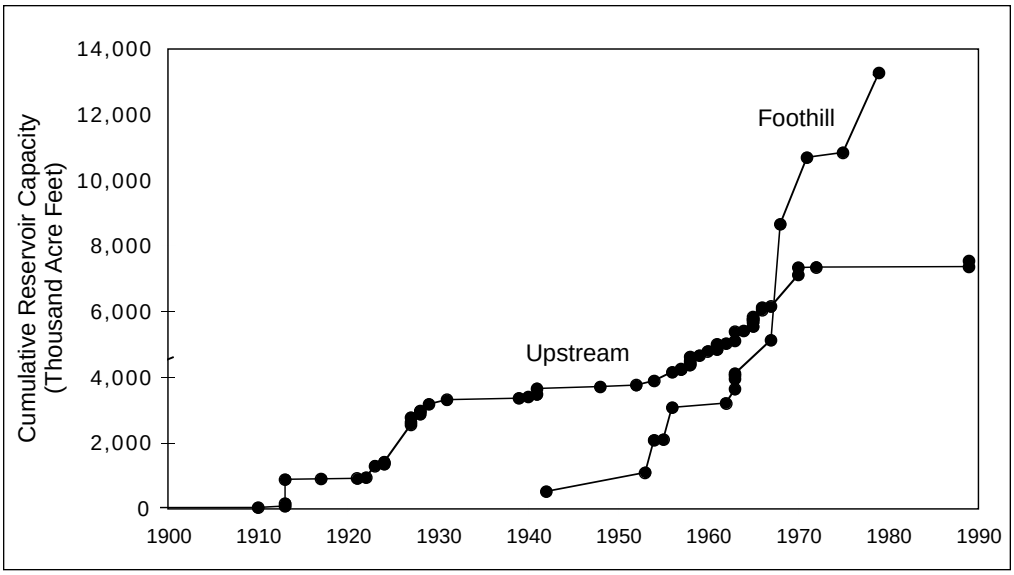


FIGURE 2.10

Cumulative capacity of reservoirs at the date when the reservoir was installed, 1910–89. Reservoirs in the foothills are shown separately from those upstream due to differences in pattern of capacities. (From volume III, chapter 23.)

stream diversions will need participation by quite different institutions from those involved in similar issues downstream.

Current Status and Future Directions

Resource utilization is permitted across most of the land and water resources in the Sierra Nevada. In contrast to largely agricultural or urban landscapes such as the Central Valley or the Los Angeles Basin, the prevailing land cover types of the Sierra Nevada are managed forests, rangeland, and alpine ecosystems that sustain many if not most elements of native biodiversity while also supporting activities based on natural resources. The history of the Sierra Nevada and recent ecological assessments suggest that Sierran biodiversity could be maintained by ecologically sound management of lands designated for renewable resource extraction, in combination with a moderate system of areas specifically reserved for native biodiversity.

Table 2.1 summarizes the economic value of different resource uses as well as the financial reinvestment and local employment associated with them. The economic value of the basic resource is much less than the total revenue of the sectors that use the resources because the total revenue is based on other inputs in addition to the basic commodities and services. Employment figures, however, are based on full revenues of each sector and are not tied only to the basic commodity or service. The key conclusion is that different patterns of resource utilization will lead to relatively large economic and employment changes. The degree to which these different sectors are complementary or competing can be assessed only at scales smaller than the whole Sierra Nevada region.

The relative importance of the major resources in terms of employment, resource values, and reinvestments varies considerably. The benefits of water use accruing outside the Sierra Nevada region account for more than half the total value of basic goods and services but provide limited employment or funds for reinvestment. The historic allocation of water rights benefits those who made the large investments in the dams, canals, and power plants that impact many of the rivers and streams of the Sierra Nevada.

Most of the value of timber stumpage, forage, and other agricultural output comes from private rather than public lands in the Sierra Nevada. Federal revenue sharing of timber receipts is the largest single source of reinvestment funds, but it is partially canceled out by the effective subsidy provided through low grazing fees on public lands.

Conservative estimates of the ecosystem value or "rent" for the large recreation and tourism industry as well as new construction are estimated at 10% of total revenue for the two sectors. The remaining 90% of the actual revenues are assigned to services over and above the estimated ecosystem value or "rent." Taxes on overnight visitors and property constitute a significant source of funds to county governments.

The 1990 census–based estimates of employment overestimate the impact of many seasonal jobs in the recreation and construction industries. After correcting for seasonality and wage differentials, commodity-related employment and service-related employment each constitute a little more than 10% of the total employment for the Sierra Nevada as a whole. In terms of reinvestments, the commodity and service sectors each provided around $20 million per year over the past decade. Each region within the Sierra Nevada exhibits a different mix of sectors in terms of relative size and trends over time.

Management practices for many forms of resource utilization have been altered over the past few decades to specifically improve the complementarity between the resource

TABLE 2.1

Estimated annual resource values and reinvestment for major ecosystem commodities and services. (From volume III, chapter 23.)

Ecosystem Commodities and Services	Resource Value (Millions of Dollars)	Percentage of Sierra Resources	Economic Sectors Benefiting	Direct Reinvestment (Millions of Dollars)
Downstream irrigation water	450[a]	20	Central Valley agriculture	[g]
Downstream municipal water	290[a]	13	Metropolitan areas	[g]
Hydroelectric power	610[a]	27	All users of electricity	[h]
Water total		**61**		
Private recreation and tourism	140[b]	6	Overall recreation and tourist sector	10
Public recreation in parks and forests	225[c]	10	Users of public recreation facilities (45 million visitor days per year)	[i]
New residential ecosystem values	110[d]	5	Total residential sectors within Sierra Nevada	10
Recreation/residential total		**21**		
Public timber	150[e]	7	Timber industry	23
Private timber	170[e]	8	Timber industry	3
Timber total		**14**		
Public grazing	8[f]	<1	Livestock industry	–7[j]
Private grazing	16[f]	1	Livestock industry	<1
Private pasture	8[f]	<1	Livestock industry	<1
Other irrigated agriculture	50[f]	2	Local agricultural processing, wineries, etc.	<1
Agriculture total		**4**		
Overall total	**2,227**	**100**		**39**

[a]Derived value of water rights.
[b]10% of 1995 total revenue estimate.
[c]$5 per day for estimated 45 million annual visitor days.
[d]10% of annual new construction value.
[e]California State Board of Equalization, 1985–94.
[f]County agricultural commissioners, 1985, 1994.
[g]Water rights are not taxed as property, hence return no value to area of origin.
[h]Hydroelectric power plants are taxed as commercial property but the assessments are very low compared with revenue generated.
[i]Public recreation in national forests, national parks, state parks, and other facilities is funded primarily from general funds rather than user fees.
[j]Public grazing fees are far below those charged by private or other public landowners.

extraction and ecological conditions. Management of forests under many new guidelines will require modified silvicultural approaches (figure 2.11). For instance, the focus may be on density management of stands to reduce the potential for insect epidemics, to reduce fuel, to maintain a diverse species composition, and to stimulate growth of larger trees. This general approach can be used in both general purpose forestlands and areas managed for late successional structure. Carefully thought out and implemented, site-specific prescriptions may be needed on all harvested lands. These prescriptions may employ both prescribed fire and mechanical removal of wood. Regeneration may occur by natural and artificial means to maintain species composition and restock stands after fire or timber harvest. The purpose of management may be to reduce fire and insect potential on general-purpose timberlands, while maintaining stands that produce both wood and wildlife habitat. In areas emphasizing biodiversity and forest structure, the focus may be on reducing fire and insects, while providing the characteristics and habitats of old forests; wood production may be a by-product.

Alterations in schedules of water release from dams, closer management of grazing animals in meadows and riparian areas, and new silvicultural techniques to preserve specific forest ecosystem characteristics reduce the conflict between resource utilization and the protection of native biodiversity. Monitoring of individual sites and the larger landscape may be required to determine the net impacts of these new approaches to resource utilization in the Sierra Nevada.

REGIONAL ECONOMIES

Income, Jobs, and the Growth of Local Economies

Over the past twenty years the economy of the Sierra Nevada region, like the population, has more than doubled. The natural and cultural environment of the Sierra Nevada has attracted new business owners, employees, and retirees to the region. From 1978 to 1993 alone, 7,500 new small businesses were started in the twelve-county area all or mainly within the SNEP core region. During the last twenty years, the major commodity-based sectors—agriculture, timber, and min-

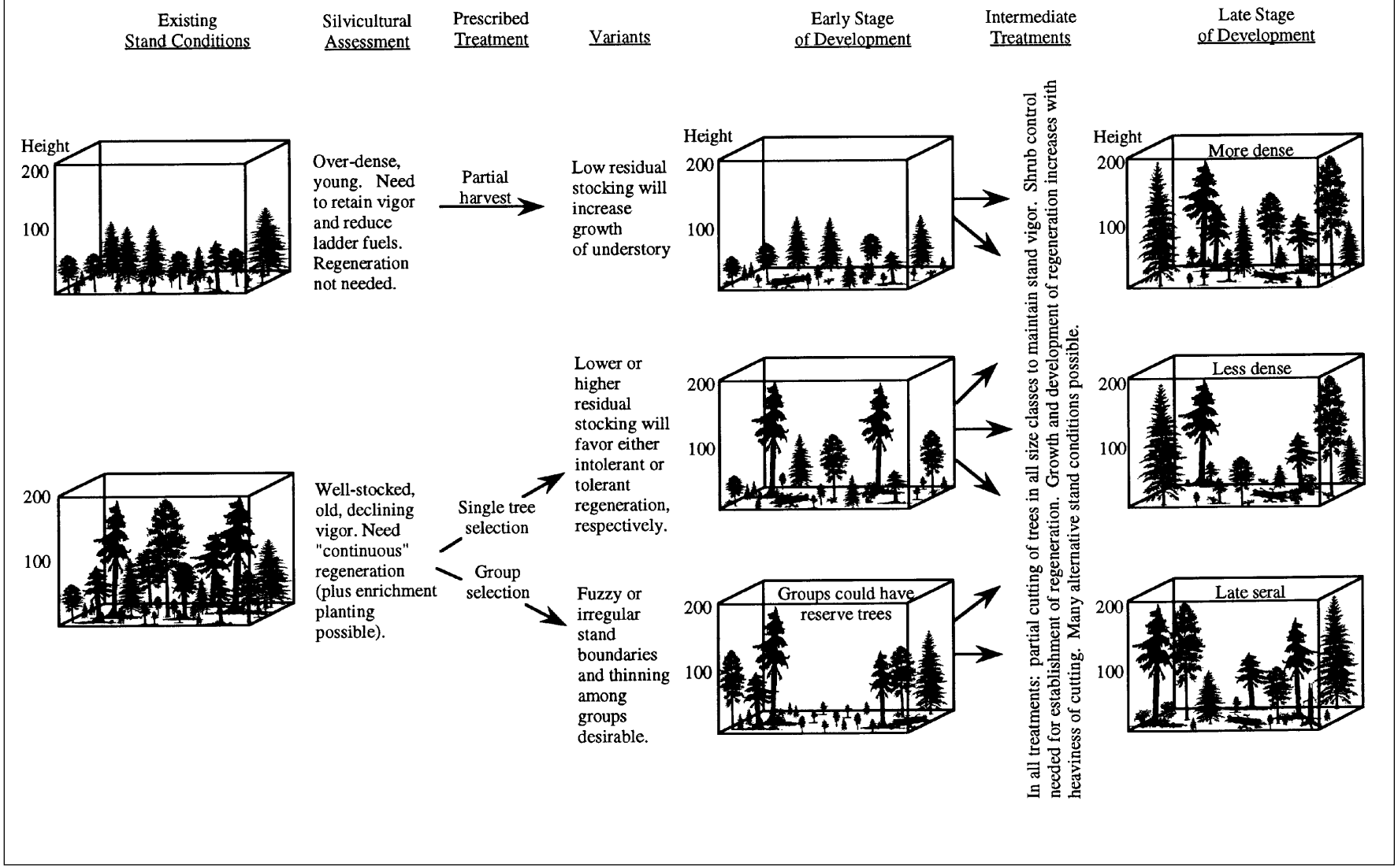


FIGURE 2.11

Schematic diagram showing how different silvicultural treatments in mixed conifer stands can lead to different structural conditions. Initial stands are uneven-aged forests. (From volume II, chapter 15.)

ing—experienced little or no growth in employment. On a rangewide basis, recreation and tourism provide more jobs and roughly the same total amount of wages as all the commodity-based sectors combined. Individual workers in the recreation and tourism sectors, however, earn lower hourly wages and work fewer hours per week on average than most commodity production workers.

The major demographic trends of in-migration of new residents employed in new businesses and retirees bringing transfer incomes have had a much greater impact on the economy than the large commodity and recreation-based industries of the region. Similarly, the economic stimulus from new businesses, commuters, and retirees is now far greater than that provided by all the commodity and recreation-based employment in the region. One of the major implications of this trend is that the economic character of the region is less influenced by the major resource industries and agencies and is becoming more similar to the diverse economy and society of California as a whole.

Patterns of demographic and economic change vary considerably across the range. By 1992, personal income levels in the Sierra portions of the counties of Nevada, Placer, and El Dorado, where 40% of the recent population growth in the Sierra took place, were on a par with the rest of the state. Personal income levels in the rest of the region have remained at 80% of state average for the past twenty years. Although all regions are now less dependent on the historically important agricultural, mining, and timber sectors, only the more metropolitan counties experienced large changes in economic status. The experience of the west-central north region may be repeated in other parts of the Sierra Nevada if they follow similar demographic trends over the next few decades.

Personal Income

In 1972, locally earned wages made up nearly 70% of all personal income in the region. Wages earned by commuters working outside of the region, interest and dividends, and government transfer payments such as social security made up the rest of personal income. By 1992, local wages constituted less than half of all personal income. Income earned by commuters, interest, dividends, and transfer payments to retired and other households now constitute more than half the total personal income in the Sierra Nevada. A significant implication of this change is that the regional economies are now less influenced by fluctuations in local employment in the cyclical commodity, construction, and tourism sectors. Differences in employment patterns still define the unique aspects of local economies but do not drive them as they did before the 1980s.

Regional Economies by Ecological Regions

Specific linkages between the economy and the ecosystem vary across the range and are most apparent at regional levels. To illustrate the regional differences, we analyzed the entire Sierra using two different types of regions: one based on socioeconomic characteristics and the other on major biophysical characteristics. The six economic regions are based on socioeconomic characteristics, following county boundaries and influence zones of major metropolitan economies. The broad-scale ecosystem boundaries follow a simple west foothill, conifer, and east-side breakdown. The population living in the foothill zone was estimated by allocating the 180 census block–based community aggregations (described later) where most people lived below the 3,000-foot elevation line that approximates the boundary between foothill and conifer ecosystems. Table 2.2 shows the population by ecological region. The east-side region includes the Greater Lake Tahoe Basin (GLTB) west of Donner Pass but does not include the small communities in Sierra, Plumas, and Lassen Counties that are topographically east of the Sierra Nevada crest and are more similar to communities on the west side of the crest. The population within each economic region is not spread evenly across the major vegetation zones.

TABLE 2.2

Regional population by ecological and socioeconomic regions. Population sums are approximate and are based on a simple classification that does not split large community aggregations. (From volume III, chapter 23.)

	Ecological Regions				
Socioeconomic Regions	**West-Foothill**	**Conifer**	**East-Side**	**Total**	**Percentage of Total**
Northern	84,000	44,000		128,000	20
West-Central South	192,000	28,000		222,000	34
West-Central North	98,000	30,000		128,000	20
San Joaquin	68,000	9,000		77,000	12
Greater LakeTahoe Basin			63,000	63,000	10
Southeast			28,000	28,000	4
Total	443,000	112,000	91,000	646,000	
Percentage of total	68	17	14	99	

TABLE 2.3

Major employment sectors (all numbers are percentages). (From volume III, chapter 23.)

	Local Services	Non-timber Manufacturing	Construction	Timber	Agriculture and Mining	Travel	Public Administration	Total
Northern	61	7	9	4	6	5	8	100
West-Central North	61	9	12	3	3	5	7	100
West-Central South	57	9	11	3	6	7	8	100[a]
San Joaquin	58	0	10	9	7	6	9	100[a]
Greater Lake Tahoe Basin	51	4	9	0	2	31	4	100[a]
Southeast	59	3	10	0	8	13	7	100
Foothills	59	8	12	3	6	5	7	100
Conifer Belt	56	2	9	8	8	8	9	100
Tahoe and East Side	53	3	11	0	6	21	6	100
Sierra-wide total	59	6	11	4	5	8	7	100

[a]Total does not equal 100 due to rounding.

Jobs and Wages

Employment patterns provide the simplest and clearest illustration of the linkages between the Sierra Nevada ecosystem and the local economies of the households, communities, and counties in the Sierra Nevada. Table 2.3 summarizes employment patterns for the different regions. Across all regions, most employment is in providing local services in sectors such as health, education, retail, wholesale, finance, real estate, and public utilities. Most of these jobs exist because other residents are bringing new income into the economy by selling goods or services outside the region, receiving income from interest and dividends, or receiving government transfer payments. The amount of income generated by retirees is primarily determined by the demographic makeup of the different regions. Income earned by selling goods or services outside the region is closely related to jobs associated with natural ecosystem products. The six nonlocal service sectors show the relative importance of the different sectors. Most construction and non-timber manufacturing employment is related to development of a relatively small area on the western fringe of the Sierra Nevada. The travel-related employment covers only 70% of total recreation and tourism employment because restaurant employment is combined with other local service employment when census-based categories are used. Employment in agriculture and mining on private land or long-term public leases is significant throughout the Sierra Nevada and is slightly larger than timber-related employment overall. Finally, the significant level in federal and state employment is dominated by jobs in resource agencies as well as the expanding number and capacity of prisons in the region.

With the exception of the travel-dependent economies in the Greater Lake Tahoe Basin and the southeast region, most of the regional economies have considerable diversity in employment. Patterns of timber dependency are not visible in any region even though they are noticeable in the ten remaining mill towns and in other communities where sawmills have shut down over the past twenty years. The population of the heavily forested areas of Plumas, Sierra, and Lassen Counties is diluted in our statistics by the much larger foothill population in the northern region. Labor mobility via commuting (the average travel time to work for every region is around 25 minutes) and permanent relocation make it difficult to define community-level economic patterns that will be stable for more than a few years.

Although basic wages contribute less than a third of the total personal income entering local economies, the sources

❄ *Social and Economic Analysis*

Sociologists and economists in SNEP used different analytical techniques and different approaches with the wide range of existing and new data available on individuals, households, communities, and larger regions within the Sierra Nevada. Complementary and sometimes contradictory conclusions are presented depending on disciplinary orientation and on which patterns are highlighted or which scales are used in analysis. For example, the socioeconomic assessment, based on the 1990 census data of 180 communities, was evaluated at the level of an individual community, a county, and several counties. The economist's approach aggregated the data to examine regionwide and temporal patterns, whereas the community sociologist explored patterns of relationships—some qualitative—at the level of the community. Personal income was a primary assessment measure in the economic approach; the measure of community capacity was used as part of the sociological assessment of community well-being.

Although it sometimes makes integration more difficult, use of diverse approaches and debate about their differences lead to a richer analysis and to identification of human and institutional issues operating at different scales.

of these wages strongly influence the character of local economies because they are more variable than income from capital assets (interest, dividends, and rent) or government transfer payments such as social security. When corrections are made for wage differentials in different sectors and wages are aggregated into similar groupings, the regional variation becomes apparent (table 2.4). Basic wages were grouped into four different categories depending on the relative dependence of wages on different uses of the ecosystem. Two categories are directly related to the ecosystem: jobs and wages related to commodity production (timber, agriculture, and mining) and those related to services (recreation and tourism). The other two categories (residents and regional) have little dependence on the ecosystem. The resident category includes wages earned by resident workers in construction and high-wage services such as financial and health services. The regional category includes wages from basic jobs that exist in any regional economy, such as manufacturing not related to local raw materials and government employment not related to resources. These latter two categories provide wage stimulus that comes from residents who choose to live in the Sierra but could live elsewhere. They enjoy the social and environmental amenities of the Sierra, hence have an indirect link to the ecosystem. But they receive most of their personal income from sources other than local jobs. The basic proportion of these jobs was estimated with the standard location quotient methodology commonly used in regional economics. Employment in government and construction is divided among the different sectors according to local economic activities. Only in the Greater Lake Tahoe Basin does a single sector (services, 59%) provide more than half of all wage stimulus. Some of the commodity sector basic wage stimulus for the San Joaquin region may be associated with agriculture in the Central Valley rather than the Sierra Nevada. Sierra-wide, the wage stimulus from jobs not dependent on the ecosystem accounted for 58% of the total.

Growth Trends

Over the past twenty years the economy of the Sierra Nevada has diversified and grown. Small businesses provide more than half the local jobs and are spread across all sectors of the economy. Manufacturing employment has remained a stable portion of regional employment because of the growth of non-timber manufacturing on the western edge of the region. Employment directly related to ecosystem-dependent commodities and services has grown principally because of the expansion of private sector recreation and capital-intensive fruit, grape, and vegetable agriculture and related value-added activities such as wineries.

Unemployment and Income Maintenance Programs as Measures of Poor Economic Conditions

Household income levels in most regions of the Sierra Nevada are lower than those of California as a whole. In addition to the large fraction of retired households, other major factors reducing income levels are seasonal unemployment and households with children but no wage earner. Figure 2.12 shows the monthly unemployment rate for four regions. Unemployment rates are higher in many counties in the Sierra Nevada than the rates for California as a whole. Nearly all of the difference is a direct result of seasonal unemployment during the nonsummer months. During the summer months, there is little “extra” unemployment compared with the state as a whole. Seasonality of many jobs related to agriculture, forestry, and recreation is characteristic of all but the more metropolitan-oriented labor markets in the region. Long-term reductions in overall unemployment in the region have always been driven by greater integration with the more robust metropolitan economies of the Central Valley.

The largest income-maintenance programs are the family

TABLE 2.4

Percentage of basic wage stimulus of nonlocal employment sectors. (From volume III, chapter 23.)

	Ecosystem Dependent		Not Ecosystem Dependent		
	Commodity	Services	Residents	Regional	Total
Socioeconomic Regions					
Northern	27	16	27	30	100
Central North	16	11	33	39	100[a]
Central South	26	17	23	34	100
San Joaquin	42	16	29	13	100
Greater Lake Tahoe Basin	5	59	23	13	100
Southeast	19	38	23	19	100[a]
Sierra-wide total	22	20	28	30	100
Ecological Regions					
Foothill	22	13	30	36	100
Conifer	37	17	28	18	100
Southeast and Greater Lake Tahoe Basin	9	52	24	16	100[a]

[a]Total does not equal 100 due to rounding.

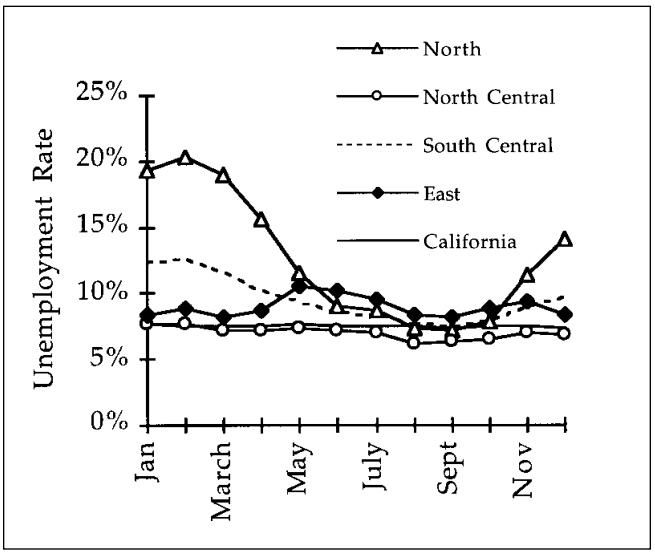


FIGURE 2.12

Monthly unemployment rates for four Sierra Nevada regions, 1990–95 average. (From volume III, chapter 23.)

group and unemployed parent programs within Aid to Families with Dependent Children (AFDC). Over the past twenty years, the ratio of AFDC cases to total population has always been below the state average for the ten counties fully within the Sierra Nevada. The large Central Valley counties that are also represented in the SNEP region (Butte, Yuba, Madera, Fresno, Tulare, and Kern) have been above the state average for most of the past two decades. Although AFDC cases are not an exact measure of poverty, the regional difference does suggest that poverty may be more serious in the lower foothills than in the higher-elevation areas of the SNEP region.

Conclusion: Regional Economy

The economic health of the Sierra Nevada depends on a diversified employment base that grows as fast as population, population growth rates that do not outstrip the ability to be served by local social (e.g., schools, health services) and physical (e.g., roads, water supply, sewage) infrastructure, and levels of resource stewardship that provide both direct and indirect benefits to a wide range of residents and business enterprises. Although personal income levels in areas of the Sierra Nevada not closely linked to major metropolitan areas are not as high as those for the state as a whole, economic and demographic diversification has generally reduced the historical problems associated with local economies dependent on only one or two industries.

COMMUNITY WELL-BEING IN THE SIERRA

Consistent with the changing settlement pattern and resource use in the Sierra, our assessment of well-being is based on a broadened understanding of the relationship of Sierra Nevada residents to resources. Our assessment of community well-being in the Sierra is unique because it focused on communities rather than county-level data. The measure of well-being is composed of two elements: (1) measures of community capacity drawn from the knowledge of local experts and (2) measures of socioeconomic status.

Communities

The SNEP social assessment is based on an improved understanding of communities and an expanded definition of human dependence on the Sierra Nevada ecosystem. Communities located in or near forests have long been called resource-dependent communities. Well-being of these communities has historically been discussed in terms of "community stability," and viewed as a function of a steady flow of timber products to ensure stable employment in the timber industry. This idea of community well-being is based on an antiquated view of forest communities, particularly for many Sierran communities today. As illustrated in the earlier discussion about major employment sectors, the well-being of a majority of Sierran communities is dependent on far more than the flow of timber products and jobs in the wood-products industry. Even communities historically reliant on the wood products industry are generally less dependent on it than they were a decade ago. This decreased dependence is due to a combination of factors, including increased concentration of the industry, declining labor demands associated with mill modernization, the movement of wood processing facilities closer to urban consumers and away from forest areas, and declining timber harvest levels. In addition, other sectors of the economy, particularly those sectors linked to recreation, tourism, and recent in-migration of retirees and others, have grown and therefore further reduced the relative impact of the timber industry. The timber industry is but one strand of the tapestry of well-being in Sierra Nevada communities.

Ecosystem dependence today may occur with no apparent economic relationship to the ecosystem. Many residents choose to live in Sierran communities because of the aesthetics, the symbolism, and even the perceived sacredness of the natural landscape. The Sierran landscape in this vein is highly valued, albeit noneconomically, and is a vital part of a human sense of place and community.

The focus on communities for well-being assessment represents a significant improvement over studies of well-being that have relied on county-level data. County data are too general for the purposes of assessing well-being at the com-

munity level because differences between individual communities are often obscured through averaging. Well-being for a single community may be very different from well-being for the parent county. For example, well-being in the community of Graeagle is higher than the average level of well-being in Plumas County, whereas the well-being in Kings Beach in the Lake Tahoe area is considerably lower than the Placer County average. In addition, county measures for foothill counties such as Kern, Fresno, Yuba, and Placer include large Central Valley populations that are not part of the Sierra.

Community Capacity Component

We invited local experts, knowledgeable about community issues, local institutions, and resources, to workshops to help assess well-being. The experts consisted of planners, community development professionals, current and former county supervisors, education administrators, business people, health and human service providers, and long-term residents with diverse backgrounds and experiences. These experts focused on community capacity assessment but also offered valuable insights into local socioeconomic measures and determining boundaries of regions and community aggregates.

Community capacity is a dynamic and multidimensional measure of the collective ability of residents to create and take advantage of opportunities and adapt to a variety of circumstances. The measure represents both a state or dimension of well-being and the dynamic ability of community residents to improve well-being. High capacity suggests a higher level of well-being for a given economic status than low capacity and also reflects a high ability of local residents to improve well-being. Experts assessed three primary components of capacity: *physical capital*, which includes physical elements and resources in a community such as sewer systems, housing stock, schools, and open space; *human capital*, which includes the skills, education, experiences, and general abilities of residents; and *social capital*, which includes the ability and willingness of residents to work together for community goals. A low-capacity community is one in which residents generally do not work well together, do not have or use existing resources effectively, and adapt poorly, if at all, to change. Low capacity, then, reflects a reduced ability to improve local well-being, including socioeconomic status.

Socioeconomic Component

Well-being was assessed in part using a socioeconomic scale consisting of five separate measures. The socioeconomic scale, developed from 1990 census data, includes measures of home ownership, education, poverty, unemployment, and homes with children receiving public assistance income. Higher levels of home ownership and education, and lower levels of poverty, unemployment, and homes with children receiving public assistance are presumed to indicate higher socioeconomic status.

The socioeconomic scale and the measure of capacity reflect different dimensions of well-being and together offer a comprehensive picture of the state of well-being of communities. It is important to point out that the combination of high capacity and high socioeconomic status does not mean that all residents of a community aggregate enjoy a high level of well-being. Similarly, low socioeconomic status and low capacity do not mean that all residents experience low well-being. Just as some families enjoy a higher level of well-being than others in the same community, some groups—ethnic, occupational, or other—may collectively have considerably lower well-being. Some of these distributional effects were identified in the capacity workshops, yet they remain beyond the resolution of much of the SNEP well-being assessment.

What We Found

180 Community Aggregations

A total of 180 community aggregations in the six regions were identified in the Sierra Nevada core area. The community aggregations are based on Bureau of the Census block group boundaries, input from county planners, and information collected in workshops with local experts. In many community aggregations a majority of the population is associated with a single community. In others, residents are linked through common service centers, community service districts, or school systems.

Well-Being in Community Aggregations

Sixteen percent of all community aggregations—comprising 18.5% of the total Sierra population—have the lowest level of well-being. These communities have medium-low to very low capacity and medium-low to very low socioeconomic status. Of these communities, 39% are located in the northern Sierra, 25% in the west-central south, and 14% in the southern Sierra, with the remaining scattered throughout the other regions. A number of these low well-being communities are formerly resource-dependent communities that, for a variety of reasons, have lost resource-based industries and jobs. The residents of these communities have, on average, low socioeconomic status and also lack the resources at a community level to take advantage of opportunities that might improve socioeconomic conditions. The low capacity in these communities is important to recognize because it suggests that these communities are unlikely to improve without substantial intervention strategies.

Seventeen percent of all aggregates, which include 15.5% of the Sierra population, have the highest level of well-being. Of these communities, 55% are in the Sacramento commuter counties of Nevada, El Dorado, and Placer. The remaining high well-being aggregates are scattered throughout the Sierra. All of the high well-being community aggregations have a high or very high socioeconomic status. Capacity scores range from medium-low to very high. Low capacity associated with high socioeconomic status is unlikely to reduce well-

The Sierra Nevada offers a wealth of recreational opportunities. Every year, millions of people visit, enjoy, and impact this national treasure. (Photo by Dwight M. Collins.)

being as much as low capacity associated with lower levels of socioeconomic status because residents of aggregations with high socioeconomic status can, and in fact do, buy their way out of situations that other communities must work internally to overcome. In some of the high socioeconomic status communities, predominantly retiree-dominated aggregates, residents buy services such as fire protection, security, and recreation programs, whereas other communities might rely on volunteer activities, the county, or the state for provision of such services. Nonetheless, among the high socioeconomic status aggregates, high capacity reflects a higher level of well-being than aggregates with high socioeconomic status and medium to low capacity.

The remaining community aggregations have moderate to moderately high well-being and can be further subdivided into three groups with varying combinations of socioeconomic status and community capacity. One group has low socioeconomic status and medium community capacity (12% of all the aggregations). Another has medium socioeconomic status and low community capacity (20% of the aggregates). The largest group of aggregates (35%) had medium capacity and medium socioeconomic status.

Well-Being in the Sierra Regions

The northern Sierra region has the lowest average socioeconomic status and capacity scores of any region. Compared to the other five regions, it has the largest proportion of people in poverty and the highest level of poverty intensity, the lowest average education level, the highest level of unemployment by a considerable margin, and the highest rate of children in families receiving public assistance. Three-quarters of all aggregations in the Sierra with very low socioeconomic status are located in this region. In contrast to these low measures of well-being, the northern Sierra has a few of the highest socioeconomic status communities in the Sierra. Lake Almanor West and Graeagle are two such examples. They are small aggregations with many high-value second homes and well-to-do retirees.

The west-central north region has the highest average socioeconomic status and the second highest average capacity score. Aggregations in this region are characterized by bedroom communities with relatively homogeneous populations of out-of-county commuters and retirees. The region has a number of commuter-dominated aggregations like El Dorado

Hills, one of the wealthiest in the Sierra, yet also has aggregations like Georgetown and Camino, locales once largely dependent on resource extraction that have in recent years grown considerably more diversified. The region also has pockets of extreme poverty within some of the aggregations. Grass Valley, Nevada City, and Placerville aggregations have relatively high poverty levels but also have high community capacities due to strong business communities within them.

The average socioeconomic status and capacity scores for the west-central south region are virtually the same as the average scores for the entire Sierra. It is important to point out that the west-central south region discussed here differs slightly from the west-central south region discussed in the "Regional Economics" section. Madera County is included in this region rather than in the San Joaquin region, as a result of expert input collected at well-being assessment workshops. The five counties of this region are linked by Highway 49, which runs north and south along the Sierra foothills and terminates in Oakhurst in Madera County. Community aggregations in this region are collectively some of the most diverse in the Sierra. There are communities, such as North Fork, historically dependent on resource extraction, and growing retiree and commuter community aggregations, including Jackson and Sutter Creek / Amador City / Volcano. There are also aggregations that have a varying mixture of retirees and economies dominated by recreation and agriculture. The southern three counties are also linked by their identification with and economic relationship to Yosemite National Park.

Community aggregations of the Greater Lake Tahoe Basin (GLTB) display a strikingly unequal distribution of wealth in this region dominated by tourism, recreation, and service economies. Slightly more than 40% of the permanent basin population resides in community aggregations with low or very low socioeconomic status, while 47% live in aggregations with medium-high to very high socioeconomic status. A vivid example is the Kings Beach aggregation, with extremely high poverty and surrounded by the much higher capacity and well-to-do aggregations of North Tahoe and Incline / Crystal Bay / Brockway. Low socioeconomic status in the GLTB is strongly influenced by low-paying seasonal jobs in the recreation, tourist, and casino industries.

The San Joaquin region discussed here differs from the San Joaquin region described previously; it excludes Madera County, which is included in the west-central south region. This region has the second lowest capacity score and a socioeconomic score that equals the average for the entire Sierra region. Despite an average socioeconomic status, there is significant poverty in the region. This region has a poverty level second only to the northern Sierra region. The Tule Indian Reservation aggregation has a low socioeconomic status, and Native Americans are almost half the population. Many of the aggregations in the southwest region were at one time economically dependent on the timber industry. Ranching and other agricultural activities remain culturally if not economically important in a number of aggregations. Local economies, however, are increasingly oriented to tourism, recreation, and retirement living. And as in many community aggregations to the north, a growing number of Fresno, Visalia, Bakersfield, and other Central Valley workers are settling in the Sierra foothills in aggregations like Lower Foothills / Millerton Lake. These new commuter residents are bringing with them both increased wealth and impacts to local communities. These changes challenge long-standing ranching and agricultural lifestyles, though conflicts are not necessarily inevitable.

The average socioeconomic status and capacity scores for the southeast region are the same as the average scores for the entire Sierra. The economies of the region are primarily based on recreation and tourism, and there is a high proportion of workers in the government and service sectors. As in the Greater Lake Tahoe Basin region, there are sharp contrasts in aggregations: the Greater Lone Pine and Antelope Valley (Walker, Coleville, Topaz) have low socioeconomic status, while Lee Vining / Mono Basin and Long Valley / Wheeler Crest / Paradise aggregations have medium-high and high socioeconomic status, respectively. This region is characterized by a land ownership pattern dominated by public agencies, primarily the Los Angeles Department of Water and Power, the Forest Service, and the Bureau of Land Management. As a result, land available for development is limited and landholding decisions generally are beyond the reach of local residents. At the same time, however, current land managers are retaining much land in open space and in a natural condition that is widely valued and upon which the region's tourist economy is established.

Conclusion: Social Well-Being

Measures of socioeconomic status and community capacity in the Sierra Nevada community aggregations reflect relatively independent components of well-being, and they measure different dimensions of it. The five-factor socioeconomic scale offers a useful though static perspective on socioeconomic status, while the measure of capacity provides a current and important complementary perspective on overall well-being. Low socioeconomic scores are found in areas where high percentages of individuals and families within community aggregations may lack sufficient socioeconomic resources to maintain a reasonable standard of living and hence experience lower well-being. Capacity provides an indication of the ability of local communities to foster an environment in which local residents can identify and address their needs and goals. Low capacity scores indicate a reduced ability to effectively address the needs of local residents and take advantage of local development opportunities that might benefit them. Low capacity therefore reflects not only lower well-being but also a reduced ability (and likelihood) by residents of aggregations to improve local well-being, including socioeconomic status. Community capacity scores are positively associated with the socioeconomic scale, but this correlation is weak. The independence of these two measures appears to be due mostly to

the critical role of social capital, which proved to be a primary determinant of community capacity.

Community capacity varies widely across the Sierra Nevada. The three components of community capacity (physical, human, and social capital) sometimes appear to be in conflict with one another. That is, where human capital is perceived as high or increasing, social capital may be low or in decline. This is particularly true in aggregations in which well-educated retirees or professionals move into an area and do not work on community issues cooperatively with one another or with residents who have lived there longer. Community history was identified as playing a role in community capacity. There are a number of community aggregations, particularly in the San Joaquin region, to which medium-high or high capacity was related to a long history and continued presence of multiple old families. In some cases, community capacity was negatively affected by divergent values of populations of different ages. Conflicts between retirees and younger families with children were noted in a number of aggregations. Retirees often demand services but resist changes that may be necessary to provide them, and retirees are often reluctant to pay for schools and other services that appear to benefit only families with children. These clashes appear to be strongest in some of the affluent, gated communities, where community capacity is negatively affected by internal strife and lack of cooperation between these two groups. In a few community aggregates, however, the knowledge, experiences, and willingness of retirees to help the community were particularly noted as positively contributing to capacity. Other volunteerism-based community services are negatively affected by populations aging in place, particularly in areas where youth leave communities and in bedroom communities with a large percentage of commuters.

MANAGEMENT SCENARIOS AND STRATEGIES

We begin this section with a scenario of future population growth and distribution in the Sierra. This analysis shows that if growth and development continue as they have to date, significant impacts to Sierra Nevada resources and a reduction of social and economic well-being are likely. We conclude the section with a strategy that outlines a general approach to improving community well-being by directly linking ecosystem management activities to Sierra Nevada communities.

Future Population Growth and Settlement

The Sierra Nevada is likely to undergo significant land conversion through continuing population growth over the next half century. The total land area converted to human settlement to accommodate 1990–2040 growth will depend upon the spatial pattern and average density of settlement, which will in turn depend upon the complex interaction of public policy, infrastructure, and land economics. Strict development controls, significant expansion of water and sewer systems and higher land prices would be likely to lead to a more intensive pattern of development with less land conversion than would occur otherwise. Continuing the existing patterns of development would consume more land than could be achieved under these conditions.

Current population growth and economic activity in the Sierra Nevada are increasingly dominated by the amenity values of resources and the environment for commuters, retirees, and people working in the recreation and tourism sectors. The impacts of future growth will therefore affect the social and economic well-being of the Sierra Nevada as well as its ecosystems. Public policies designed to manage growth will need to encourage patterns of development that reduce the impacts of human settlement.

Land conversion due to human settlement can have a wide range of indirect effects on ecological structure and function. The most important of these in the Sierra Nevada is associated with impacts on the fire regime in both settled areas and adjacent wildlands. Human settlement affects the structure and level of fuel load, viability of presuppression fuel-management strategies, ignition risk, availability of suppression resources, and the manner in which suppression efforts are allocated and deployed (e.g., to protect structures rather than wildlands). Each of these will in turn affect the future risk and characteristics of fire in the Sierra Nevada. Vegetation management in the "urban forest" of areas converted to human settlement can either decrease or increase fuels in the urban-wildland intermix zone. Without additional research on the relationship between alternative patterns of human settlement and specific ecological impacts, it is difficult to forecast ecological implications of continuing existing patterns of development and using a range of alternative growth management policy mechanisms for mitigating those impacts.

General relationships can still be inferred, however, based on theoretical and empirical research to date. In particular, land conversion causes at least five direct effects on vegetation and wildlife:

1. Reduced total habitat area through direct habitat conversion
2. Reduced habitat patch size and increased habitat fragmentation
3. Isolation of habitat patches by roads, structures, and fences
4. Harassment of wildlife by domestic dogs and cats
5. Biological pollution from genes of non-native plant species

In addition to these direct effects upon vegetative composition, structure, and function (which in turn affect wildlife habitat and wildlife viability), land conversion for human

settlement has several direct effects on hydrologic regimes that could be important:

6. Increased impervious surface and increased peak runoff
7. Increased heavy metal and oil runoff from impervious surfaces
8. Increased risk of ground-water and / or surface water contamination through septic effluent disposal
9. Decreased ground-water flow to surface water system due to ground-water pumping
10. Modified surface water flow due to irrigation, septic system effluent disposal, and treated wastewater discharges

Scenarios

Without assuming any linkages to specific policies or market conditions, six alternative distributions of future population by housing density class were considered. These were based upon GIS analysis of the distribution of population by housing density class under the following: (1) 1990 Sierra Nevada census blocks; (2) 1990 Nevada County census blocks; (3) 1990 El Dorado County census blocks; (4) Nevada County General Plan; (5) El Dorado County General Plan Project Description; and (6) El Dorado County General Plan Alternative. The three General Plan distributions were based on the planimetric estimates of area designated for "buildout" at specific density classes in the General Plan land-use maps but did not account for the greater development in some density classes that is likely to take place due to existing parcelization. They therefore overstate the degree of future concentration.

Four alternative future growth projections from 1990 to 2040 were considered for each of the forty-six county census divisions (CCDs) in the analysis: (1) based on each CCD's 1970–90 share of overall county growth; (2) based on each CCD's 1970–80 share of overall county growth; (3) based on each CCD's 1980–90 share of overall county growth; and (4) a lower projection at two-thirds the first described projection, which was the approximate absolute growth rate historically from 1970 to 1990 for the entire Sierra Nevada. Combined with the six alternative population distributions by density class, these four alternative population projections for 1990–2040 result in twenty-four possible land-conversion estimates for each of the forty-six CCDs in our analysis for the year 2040. The resulting 1,104 cells of land-conversion estimates are a bit overwhelming for presentation, however, and many of the population distributions by housing density class are similar to one another. Therefore, the set was simplified to four scenarios:

A. Low population growth with compact human settlement patterns (Low-Compact)
B. High population growth with compact human settlement patterns (High-Compact)
C. Low population growth with sprawling human settlement patterns (Low-Sprawl)
D. High population growth with sprawling human settlement patterns (High-Sprawl)

The most "compact" population distribution was the Nevada County General Plan, in which 71.3% of the population is accommodated in the highest housing density class (640+ dwelling units per square mile). Note that this is a significantly higher fraction of the population than there was in this class in 1990, when Nevada County's distribution was not significantly different from that for the entire Sierra Nevada (figure 2.13). The "compact" distribution assumed in the Nevada County General Plan still consumes roughly a quarter-acre per person in the highest housing density class in an average of roughly two dwelling units per acre. This "compact" pattern is therefore considerably less dense than most suburban subdivision densities in metropolitan areas. This pattern likely reflects a bimodal distribution within this density class, where there are clusters of parcels close to one acre in size (with on-site domestic well water and on-site wastewater disposal through septic systems) and around one-quarter acre in size (with public water and sewer). Unfortunately, it was not feasible to disaggregate housing density below this level for the analysis. Doubling the average density for this class (through an infrastructure-directed development strategy) could reduce the land conversion estimates for the "compact" scenarios by 50% in the highest-density class. It would have little effect, however, on the total land area converted by human settlement at any of the lower thresholds for human settlement. As noted in the more detailed assessment, the Nevada County General Plan also underestimates the amount of land that is likely to be developed at lower densities due to existing parcelization. The quarter-acre-per-person estimate for the highest housing density class is therefore a reasonable basis for estimating the land-conversion effects of "compact" human settlement patterns across the entire Sierra Nevada.

The most dispersed ("sprawl") population distribution was the 1990 Sierra Nevada census block distribution, in which 39.5% of the population resided in the highest housing density class. We therefore assumed continuation of this existing distribution across all CCDs in the Sierra Nevada for our "sprawl" scenarios of human settlement. This assumption allowed us to estimate the total land area required in each CCD to accommodate 1990 to 2040 population growth if existing patterns of human settlement were to continue. Land tenure relationships constrain the potential to expand the land area converted to lower housing density classes, however, so the lower housing density classes generally increase their average densities within their density ranges rather than expand in area (e.g., land in the class with ten to twenty dwelling units per square mile might move from twelve dwelling units

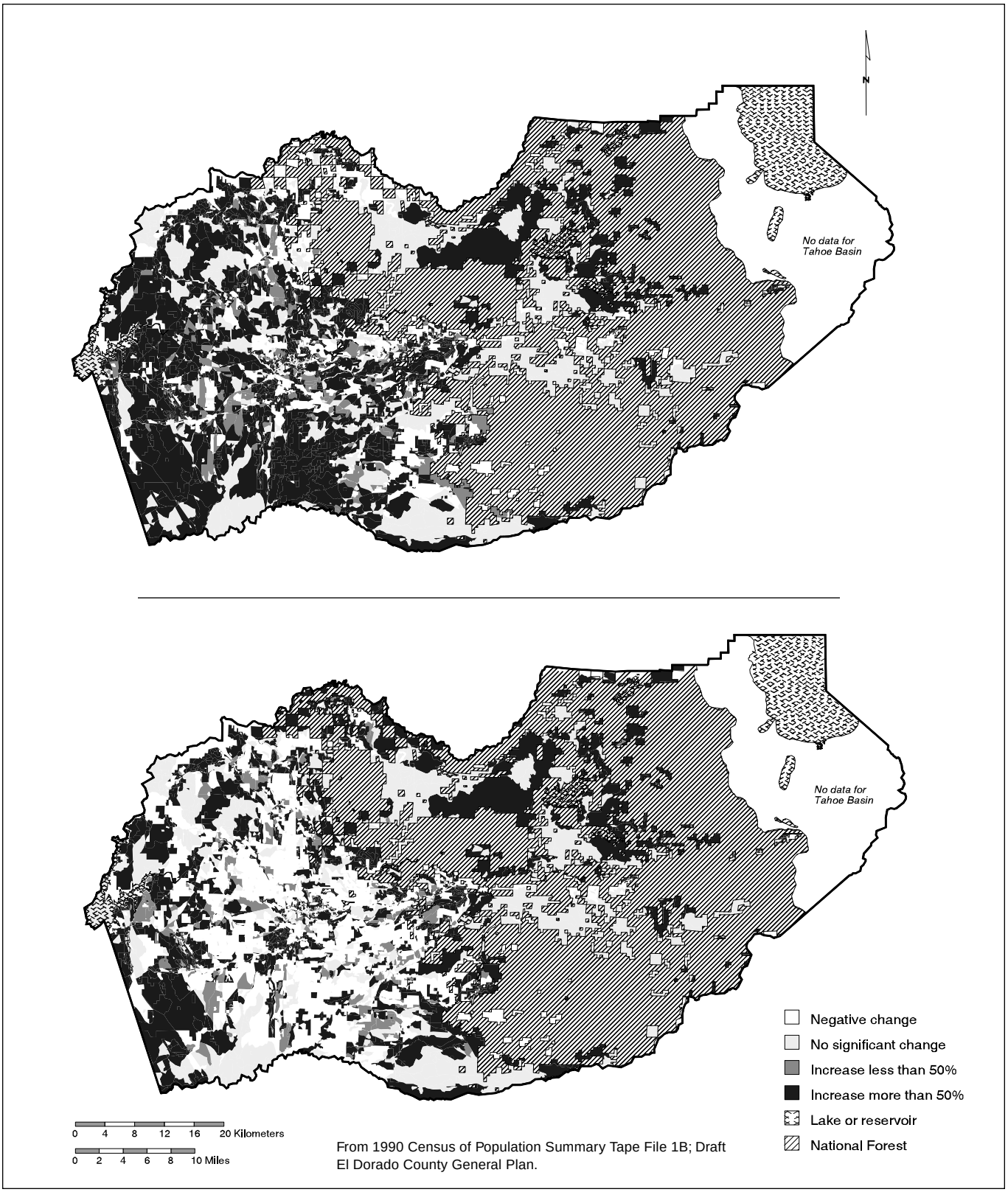


FIGURE 2.13

Projected change in relative housing density, El Dorado County, from 1990 to buildout, based on General Plan alternatives. *Top:* Projection based on primary project model. *Bottom:* Projection based on alternative project model. (From volume II, chapter 11.)

to eighteen per square mile). This analysis therefore estimated land converted to human settlement only above the density threshold of twenty dwelling units per square mile (32 acres per dwelling unit).

Implications

Based upon these four scenarios, the range of additional land conversion required to accommodate population growth from 1990 to 2040 (beyond the land area already converted for human settlement in 1990) is estimated to be:

- 106 to 579 square miles at an average density of at least 640 units per square mile
- 299 to 875 square miles at an average density of at least 160 units per square mile
- 480 to 1,655 square miles at an average density of at least 80 units per square mile
- 477 to 2,957 square miles at an average density of at least 40 units per square mile
- 134 to 5,105 square miles at an average density of at least 20 units per square mile

The Low-Compact scenario (A) always represented the lower bound of our range and the High-Sprawl scenario (D) always represented the higher bound of our range, with the exception of the 640+ dwelling units per square mile threshold. For this one exception, these two extreme scenarios resulted in approximately the same land area conversion, while the Low-Sprawl (C) scenario resulted in the least land conversion and the High-Compact (B) scenario resulted in the most land conversion. This result primarily reflects the fact that the "compact" scenarios concentrate 71.3% of the total population into the highest housing density class. The "compact" scenarios therefore show more land area converted to human settlement in the highest housing density class, but they still show less land area converted to human settlement in all of the other housing density classes. This is made clear at all of the other density thresholds.

The social, economic, and ecological ramifications of future development will depend upon specific spatial patterns of human settlement in relation to existing communities, infrastructure services, vegetation and habitat types, and watershed boundaries. As discussed earlier, our understanding of those relationships is still poor at this time. It is therefore impossible for us to characterize the specific impacts that population growth and human settlement will have in the Sierra Nevada. The range of impacts could be quite significant, however, if existing development patterns continue. Continuing the existing pattern of "sprawl" development with a high-growth scenario could result in human settlement on nearly half the private land in the Sierra Nevada (6,846 square miles) at an average density of at least one housing unit per 32 acres. A low-growth scenario with the existing pattern of "sprawl" development would reduce that figure by 44%, to just 3,817 square miles. This is still more than twice as much land area as the 1,741 square miles affected by human settlement at that density in 1990.

Even modified settlement patterns are forecast to result in significant land conversion from 1990 to 2040, suggesting that the scale of population growth alone could lead to significant impacts. A high-growth scenario with a more "compact" form of settlement would still result in nearly a doubling of land converted to human settlement, from 1,741 square miles to 3,363 square miles at an average density of at least one housing unit per 32 acres. A low-growth scenario with a more "compact" form of settlement, on the other hand, could nearly be accommodated within the land area already converted to human settlement at an average density of at least one housing unit per 32 acres in 1990. Through infill and carefully targeted density transfers, the low population forecast for 1990–2040 would require only 1,875 square miles (only 8% more than in 1990). Both the scale and pattern of human settlement will therefore affect—and must therefore be considered by—local, state, and federal land and resource management agencies with responsibility for the health and sustainability of Sierra Nevada ecosystems.

These estimates of land conversion associated with human settlement from 1990 to 2040 are not uniform throughout the Sierra Nevada. They reflect the distribution of population forecast by the Department of Finance (DOF) for each county and the allocation of that population by our allocation models to each of the CCDs in our analysis. In general, the land most likely to be converted to human settlement is primarily in the western foothills and within commuting distance of rapidly growing cities in the Central Valley. Some specific vegetation (Holland) types and Wildlife Habitat Relationships Model (WHR) types are therefore more threatened by human settlement than others, reflecting the nonrandom spatial distribution of growth, private ownership, and vegetation.

The ultimate environmental effects of General Plan buildout will depend upon the spatial patterns of development and the infrastructure used to provide services to that development. Both these characteristics are in part a function of local land-use planning and policies, which are central to the General Plan process. Detailed assessment of that process was completed for the recently adopted Nevada County General Plan and El Dorado County General Plan. These two counties have experienced very rapid growth over the past thirty years and have committed significant resources to updating their plans over the past five years. Despite their efforts, however, the environmental impact reports for the two General Plan updates (together with independent analysis described in volume II, chapter 11) show that future development will result in significant environmental impacts and significant shortfalls in infrastructure investments to mitigate those impacts. The existing institutional mechanisms for mitigating the anticipated impacts of future development in the Sierra Nevada

appear to be inadequate. Significant changes in local land-use and infrastructure investment policies are therefore likely to be necessary to achieve the lower-impact scenarios associated with the more compact form of development described earlier. Without those significant changes, the existing patterns of development are likely to continue to dominate and to result in at least a doubling of the total land area affected by development at an average density of at least one unit per 32 acres.

Strategy: Improving Community Well-Being through Ecosystem Management

A fundamental SNEP charge is to maintain the health and sustainability of Sierra Nevada ecosystems while meeting human needs. Another way to view this charge is to maintain the health and sustainability of Sierra Nevada ecosystems that *include* human communities. Healthy ecosystems contribute to healthy communities, and healthy communities are better able and more likely to maintain healthy ecosystems than unhealthy communities. Health of communities is discussed here as well-being.

Ecosystem management activities may be pursued in many different ways, but the most effective ecosystem management will maintain a healthy and sustainable ecosystem *and* improve community capacity and well-being. Building this reciprocal relationship is a first step toward genuinely integrating humans with natural ecosystems, as well as strengthening communities, which, in turn, will lead to better ecosystem management and protection.

Low well-being in the Sierra is the result of many factors, some of which have played out decades ago in resource boom-and-bust cycles and others that have little to do with management of the ecosystem. Nevertheless, well-being of community residents can be improved by management of the Sierra Nevada resources that is tailored to meet both ecosystem objectives and community well-being objectives, including the well-being in communities that have few jobs in traditional resource sectors.

Goal and Approach

This strategy follows a general approach that links ecosystem management activities to Sierra Nevada communities to improve community well-being. Ecosystem management activities are specific to community capacity because use of these activities for improving local well-being is partly dependent on community capacity. What works in a community with high or medium capacity may not be successful in a community with low or very-low capacity. Improving community capacity, one dimension of well-being, is a goal as well. Lower capacity communities are less able to respond to assistance or intervention and improve well-being. Low capacity and low socioeconomic status communities often require intensive and long-term assistance to improve well-being beyond ecosystem management. Community and economic development projects of any sort must address underlying reasons for low capacity if they are to be successful at improving long-term well-being.

In the short term, ecosystem management activities are most likely to improve well-being in communities with moderate levels of well-being already. Hence, communities with low socioeconomic status and moderate to high levels of capacity should receive very high priority for expansion of ecosystem management activities that contribute to well-being. These communities have not yet lost the resiliency they need to take advantage of opportunities that will raise their low socioeconomic status as well as capacity. Understanding the local conditions, including community capacity, can lead to development of more effective ecosystem management activities.

Components of Ecosystem Management

Ecosystem management involves various activities. It is useful to outline these activities to make clear the nexus between ecosystem management and communities and how management might be structured to improve community well-being. For example, with three levels of community capacity (high, medium, and low) and eight broad categories of ecosystem management activities (research, planning, survey and assessment, monitoring, maintenance and restoration, recreation and tourism, commodity extraction / processing / production / use, which includes primary and secondary production processes, and reserves) there are twenty-four combinations depending on capacity and a single activity for a community. Any ecosystem activity will need to be modified to fit the particular circumstances and the context of the community. Diverse communities such as those in the Sierra require diverse approaches to improving well-being. No single approach is complete or adequate. Several examples of the relationship between capacity and ecosystem activities are offered in the next section.

These ecosystem management categories are incomplete; they are offered to show a range of ecosystem activities and to help broaden how we think ecosystem management can contribute to community well-being. The category of monitoring includes biological and ecological as well as social and economic monitoring. Maintenance and restoration activities apply to watersheds, forests, and roads, and include activities such as general erosion control, watershed restoration, stand density management, building of fuel breaks and other fuels maintenance, fish and other wildlife habitat improvement, and mining reclamation. Commodity extraction / processing / production / use includes activities associated with wood products, special forest products, forage, water and minerals, and other commodity resources. The category of recreation and tourism encompasses dispersed and nondispersed recreation and activities associated with destination resorts and tourism services more generally. The category of reserves may be viewed as less an activity than a

land-management classification, but it is listed here because traditional reserves (e.g., wilderness) and nontraditional reserves, such as those managed for biodiversity or for the protection of unique cultural areas, involve different management activities that can and do contribute to community well-being.

Examples of Linking Ecosystem Management Activities with Community Capacity

A few examples are offered to describe how ecosystem management activities linked to community capacity can be tailored to improve community well-being. In virtually all categories of ecosystem management, successful linkage will require a change in investment patterns in resources. Natural resources have historically been used with inadequate reinvestment or underinvestment in the resource base, by both public and private entities. This ongoing process is further exacerbated by recent cuts in federal land-management budgets. New funding mechanisms that tie resource use to reinvestment in the sustainability of the resource base must be developed, or it will be difficult to ensure sustainable ecosystem management activities, much less tie them thoughtfully to concerns for community well-being.

The ecosystem management activities that fall into the categories of research, planning, survey and assessment, and monitoring have generally been the province of government agencies, private landowners, managers and scientists. Increasingly, there are local watershed- and community-based groups that want to become involved with these activities. Local collaborative and consensus-based groups can make significant contributions to ecosystem research, planning, survey and assessment, and monitoring and in the process improve community capacity and local well-being. Medium and high capacity communities are far more likely to independently spawn and support watershed- and community-based groups than low capacity communities are. Because all of these activities require significant training, the capacity to train workers will prove vital in being able to complete the work itself. Low capacity communities are more likely to lack training facilities and resources, hence will have a harder time participating in these types of ecosystem management activities.

Watershed maintenance and restoration is a combination of equipment-intensive and labor-intensive activities. High capacity communities will benefit most from watershed reinvestment strategies. Low capacity communities are likely to require training to be conducted by agencies without charge and a consortium of rural development partners such as Vocational Training, Job Training Development, and local economic development organizations in maintenance and restoration training activities. Access to capital for operating expenses and equipment in low capacity communities will be problematic because financing is impossible without secured contracting experience. Contractors will generally have to start with labor-intensive activities and then pool resources through business incubator frameworks to develop toward equipment-intensive ecosystem work. Multiyear and multitask stewardship contracting in a watershed designed to favor local contractors and workers can be used to increase local community access to ecosystem work. Increased watershed maintenance and restoration activities are likely to offer opportunities to develop "ecosystem worker" training programs that can enhance access of local workers to watershed rehabilitation projects and other forest health projects. These are just a few activities associated with watershed improvement that can lead to improved local well-being. Other maintenance and restoration activities include wildlife habitat enhancement, fuels treatment, timber stand improvement, and other forest health work.

In the commodity extraction / processing / production / use category, ways of improving local well-being would include managing nearby areas with significant resource degradation or ecological or cultural sensitivity using "community management." These local communities could develop partnerships with local land managers to develop joint-management agreements. Forest commodity harvest and production activities can be bundled with ecosystem health initiatives using a community management or stewardship framework. This structure would help link commodity harvest and production to payment for ecosystem service and maintenance work. High capacity communities are more likely than low capacity communities to participate in community management, but increasing local access to forest products generally can assist low capacity communities. Other ways of making the link between forest commodity use and local communities include using an approach in which a product stream from stewardship lands is made available locally for processing and secondary manufacturing development; offering price incentives to processing facilities that demonstrate more worker years per million tons processed in low well-being areas; and developing incentives and seeking ways of providing capital for the creation and expansion of local firms for value-added work.

Special forest products are harvested on public land by permit, not high bid. Some areas of a forest can be limited to use by traditional forest product harvesters with "special use" permits under which they would be responsible for care and sustainable management of the resource and harvest. This permit process would provide access to products and would create broad management responsibilities. An objective of this approach is to build incentives and responsibility for forest health and to focus attention on the condition of the land rather than on a single product.

Ecosystem reserves are conceived here as broader in purpose than wilderness and parks and include areas that are managed for biodiversity and cultural objectives. While management is directed to ensure the maintenance or sustainability of cultural or natural resources in these areas, other human activities may be allowed. For example, in an area identified as important for maintaining Sierra Nevada

biodiversity, some human settlement can be allowed so long as it does not conflict with and is consistent with long-term biodiversity objectives. Settlement in such a reserve must be approached conservatively, and human impacts must be continually monitored and reassessed. Rather than reserving areas for exclusive use and trading off human use against reserve values, this approach to reserves explicitly acknowledges the connection between humans and their natural environment and makes sustainable ecosystem management and protection of biodiversity part of the living experience.

Implications

Ecosystem management can and should be designed where possible to contribute to community well-being. Resource management that includes the objectives of improving human well-being does not require a trade-off with ecosystem health and sustainability objectives. In fact, building this linkage can result in community self-interest ensuring resource stewardship and sustainable resource management, including protection of biodiversity. Without deliberate restructuring of the relationship between ecosystem management and local communities, it is unlikely such a relationship will develop on a meaningful scale. Because the success of ecosystem management is largely dependent on who takes responsibility for it and carries it out, linking it to local communities that benefit from it can build powerful local incentives and improve the likelihood that it is done well.